The LDSS Future

Richard Bower

Dept. of Physics, University of Durham, DH1 3LE, UK

Abstract

The aim of this talk is to make you think about the future of LDSS. Developments, such as charge shuffling currently being developed at the AAT, will allow LDSS-type spectrographs to obtain 100-200 spectra per exposure. I will argue that, with this level of multiplex advantage, a faint object spectrograph on a 4-m telescope has an important future role performing spectroscopic follow-up of candidates selected from deep imaging surveys.

Key words: LDSS; multi-object spectroscopy; faint object spectroscopy; grism spectroscopy

1 Introduction

I'd like this talk to promote discussion of the future of LDSS-2. At the outset, I should make it clear that I am not an instrument specialist — rather I am giving this talk as an astronomer who wants to get a job done. Far from withdrawing the capabilities of LDSS-2, we should be thinking in terms of upgrading it. LDSS-2 technology is far from static and I will try to give a flavour for the recent advances.

LDSS stands for Low Dispersion Survey Spectrograph (Allington-Smith et al. 1994). It is designed as an imaging spectrograph. The normal mode of use is to place a mask at the focal plane of the telescope. At the position of each object of interest, a slit is cut. The light passing through the slit is dispersed using a grism (basically a transmission grating) and the light refocused onto the detector. For each object, the observer obtains an object spectrum with adjacent sky spectra. The wavelength range appearing on the detector can be controlled by the placing of the slit.

The key aims of this design concept were:

- high throughput

- accurate sky subtraction
- high multiplex
- small object separations

At the time that it was built, the instrument represented the state of the art these areas, but it is now 7 years old and, although still powerful in its own right, recent developments make the concept even more powerful.

2 The Scientific Future of LDSS

With the advent of the GEMINI 8m telescopes, why should we continue to need an LDSS-type spectrograph on the WHT? Firstly, let's address a question raised earlier during the meeting. GMOS has similar design goals to LDSS, so why continue with a 4m class telescope. The answer is surely that GEMINI time is extremely limited. Many projects are perfectly matched to the depths reached in 1-2 hr exposures on 4m telescopes. It makes no sense to use GEMINI time for these projects. With 1/4 hr exposures, the inevitable acquisition time will match the exposure time. GEMINI resources are far too precious for this abuse.

It's better to think of what we should want from a 4-meter spectrograph. Surely the future role of 4m telescopes lies in spectroscopic surveys; perhaps following up potential targets identified in the WFC imaging survey. The most interesting of these objects then feeding on to the GEMINI telescopes.

LDSS makes the ideal survey spectrograph. Although its field of view is not matched to the WFC, the key point is to be able to match the surface density of targets at the spectroscopic limit. By the nature of its design the system is highly efficient, and, with the sky subtraction techniques being developed at the AAT, the concept is also possible of very high object packing densities.

To illustrate the kind of project that is well suited to the spectrograph, here is a short, by no means exhaustive list, that is clearly biased to extra-galactic applications.

- galaxy evolution in clusters $0.1 < z < 0.3$ (the Butcher-Oemler effect)
- PN in galaxy haloes
- dwarf galaxies in lower redshift clusters and groups
- environments of quasars
- identification of X-ray sources.

The common requirement in all of these projects is observation of relatively faint objects with high surface densities. A similar list can be constructed for galactic targets.

3 Developments in LDSS Technology

The technology of imaging spectrographs is not static, and the multiplex of this type of spectrograph can now be greatly enhanced. LDSS++, recently commissioned at the AAT, shows the way forward (Glazebrook, 1999). The enhancements of the original spectrograph are:

- efficient VPH grism technology
- nod and shuffle sky subtraction
- microslit mask design
- red efficient optics and CCD detectors.

VPH technology increases the efficiency of the transmission gratings by eliminating the effects of shadowing in a conventional blazed grating. As well as the direct benefit of high through-put, it opens the possibility of using LDSS-type spectrographs at higher resolutions: important for the I and Z bands where large gains can be made by resolving out the OH line emission. More discussion is given in J. Bailey's contribution (2000, this issue).

Nod and shuffle sky subtraction is a powerful technique that uses the possibility of shuffling charge across the surface of a CCD detection on very short timescales. The idea is to cut two holes (rather than slits) for each object. As the telescope nods the objects between their holes, the charge on the CCD is moved so that two images are obtained, accumulating the two positions in parallel. It is not necessary to use micro-slits (the object can be nodded along a conventional slit), but using micro slit principle each object need only occupy a small region of the CCD. Karl Glazebrook's experiments found that a 1.5×1.5 square works well.

In the micro-slit case, objects need only be separated by $2''$. This allows very high object densities, with 100 objects being observable within a 10' field. This is comparable fibre feed spectrographs; with the advantage that the objects may be much closer together. Further increase in the multiplex advantage are possible using band-width limiting filters (Figure 1).

Many of the science objectives of this type of spectrograph benefit from improved red efficiency. For example many programmes may be aimed at detecting redshifted Hα. Currently, the red performance of LDSS++ is limited by the transmission of its optics. Revised coatings could allow such an instrument to work from the blue through to the near IR, possibly being compatible with INGRID as a detector.

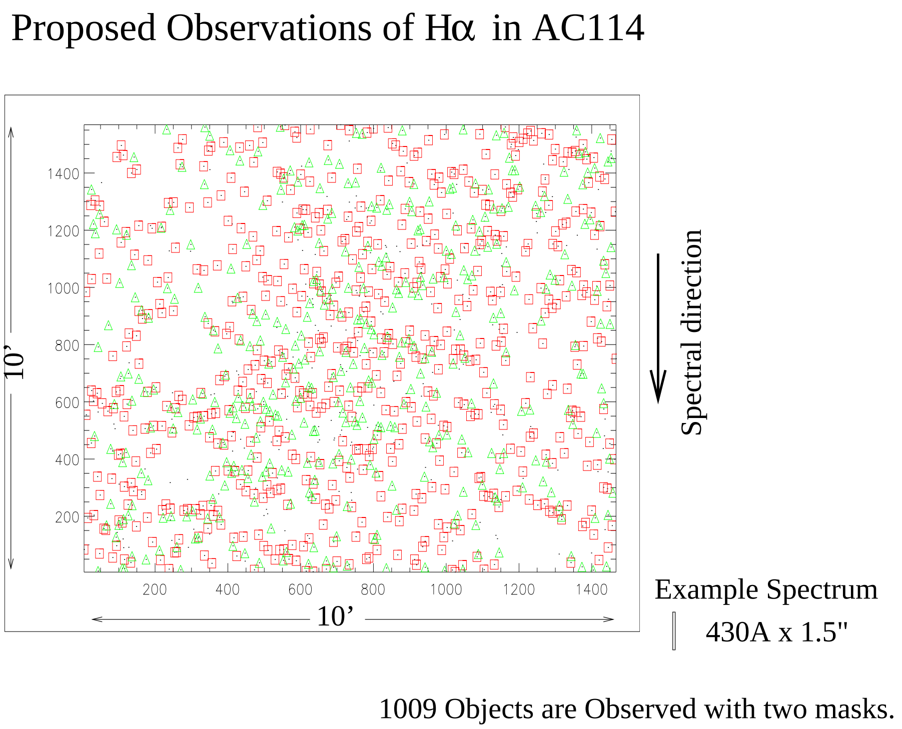

Fig. 1. An illustration of the huge multiplex advantage that can be obtained by combining the microslit technology with band width limiting filters. The aim of this programme is to study Hα emission in the intermediate redshift cluster AC114 ($z = 0.31$). Squares and triangles mark the positions of mircoslits in two separate masks. In two exposures spectra of 1009 spectra will be obtained.

4 Summary

I hope this talk has made you think about the way forward for spectroscopic instrumentation at the ING. The future role of the WHT demands a multi-object spectrograph with a wide-field and a close-packing of objects. There are two ways of designing such a spectrograph: using fibres or developing the LDSS concept. Both approaches have their own advantages, but the imaging spectrograph design has inherently better through-put and greater flexibility. The essential optical design requires a collimated space: this can be used not only for grisms, but also for tunable narrow-band filters.

References

[1] Allington-Smith J. et al. 1994, PASP, 106, 983.

[2] Bailey, J., Taylor, K., Robertson, G., Barden, S. 2000, NewAR, these proceedings.

[3] Glazebrook K. 1999, AAO Newsletter, March 1999.